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TITLE: T type gate mfr. using double exposure e.g. MESFET, HEMT - comprises shifting photomask position between two exposures

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PATENT-FAMILY:

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INT-CL (IPC): H01 L 21/30; H01 L 21/338; H01 L 29/43; H01 L 29/812

ABSTRACTED-PUB-NO: JP 07201889A
BASIC-ABSTRACT:

The T type gate is formed on a GaAs semiconductor substrate (10). The first photo resist film (20) is formed on the substrate. The first photo resist film is patterned and exposed using a mask (30) with an opaque domain (31). The mask is moved along one side so that the domain which was blocked by the opaque domain is exposed. By shifting the mask to another side the domain is exposed. By the above referred method two domains (23) are exposed once.

The exposed film is developed and the clearance for the T shaped gate is formed. A heat treatment is given to the substrate at this stage. The second photo resist pattern is formed and the horizontal portion of T shape is exposed using a suitable mask. The second photo resist pattern is developed and the metal layer is formed corresponding to horizontal portion. The remaining second photo resist is removed.

ADVANTAGE - Improves pattern resolution. Reduces number of process.

L5 ANSWER 7 OF 34 CAPLUS COPYRIGHT 2003 ACS
Full Text
AN 2000:559809 CAPLUS
DN 133:128623
TI Fabrication and etching of a T-gate semiconductor device using a double exposure technique
IN Yang, Chon-wook; Kang, Suk-bong; Park, Chol-soon; Park, Hyung-moo
PA Korea Electronics + Telecommunication Research Institute, S. Korea
SO Repub. Korea, No pp. given
CODEN: KRXXFC
DT Patent
LA Korean
FAN.CNT 1

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PI KR 9707105	B1	19970502	KR 1993-27214	19931210
JP 07201889	A2	19950804	JP 1994-306543	19941209

PRAI KR 1993-27214 A 19931210

AB A method of fabricating a T-shape gate using double exposure includes the following steps:. (a) coating photoresist layer on a semi-insulating GaAs substrate, firstly exposing the photoresist layer using a photomask on which an opaque pattern is formed and optical stepper, moving the substrate by a predetd. distance and secondarily exposing the photoresist layer to form a fine unexposed region therein. (b) developing the unexposed portion of the photoresist layer to remove it, thereby forming a fine line width of the photoresist layer. (c) hardening the photoresist layer having the fine line width at a temp. of >150°, to form a hardened photoresist layer. (d) coating photoresist on the hardened photoresist layer, the photoresist layer having a pattern wider than the fine line width, the photoresist pattern having inverse-image slope, and exposing and developing the photoresist layer using the optical stepper and photomask. (e) cleaning the substrate and depositing metals thereon. (f) lifting off the metal layer on the photoresist layer by dipping the substrate in a photoresist solvent and removing the hardened photoresist layer through dry etching process using O plasma, thereby forming a T-shape gate.

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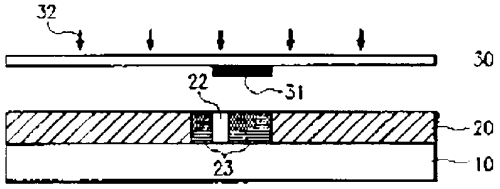
最終頁に続く

(54)【発明の名称】　二重露光によるＴ形のゲートの製造方法

(57)【要約】

【目的】　この技術は半導体素子における二重露光を利用するＴ形のゲートの製造方法に関するものである。

【構成】　その方法は半絶縁のGaAs基板上に形成された第１フォトレジスト膜に対して、フォトマスク位置をずらせつつ２回の露光を行う。２回とも露光された領域、１回のみ露光された領域２３および２回とも露光されなかった領域２２では、現像工程における現像の程度が異なってくる。これによってＴ形状の溝を効率的に形成できる。



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【特許請求の範囲】

【請求項１】　二重露光を利用するＴ形のゲートの製造方法において、

半絶縁のGaAs基板を準備する工程と、

前記基板上に第１フォトレジスト膜を形成する工程と、

不透明の領域が具備されたフォトマスクを利用して１次露光を実行して前記第１フォトレジスト膜内に第１露光されなかった領域を形成する工程と

前記Ｔ形のゲートの長さを考慮して少し移動された前記フォトマスクを使用して第２次露光を実行して　前記第１露光されなかった領域内に第２露光されなかった領域を形成し、そして前記第２露光されなかった領域の両側には一回露光された領域を形成する工程と、

現像工程を実行して現像されたＴ形の凹部分をもつ第１パターン化されたフォトレジスト膜を形成し、前記現像されたＴ形の凹部分は前記第２露光されなかった領域と前記一回露光された領域の一つの部分を除去することによって形成される工程と

熱処理工程を実行する工程と、

前記第１パターン化されたフォトレジスト膜上に第２パターン化されたフォトレジスト膜を塗布し、前記第２パターン化されたフォトレジスト膜が下の方向に広げられる開口部をもつ工程と、

前記第２パターン化されたフォトレジスト膜上に　そして前記基板の露出された表面上に金属層を塗布する工程と

前記第２パターン化されたフォトレジストを除去する工程とを包含することを特徴とするＴ形のゲートの製造方法。

【請求項２】　前記第２パターン化されたフォトレジスト膜はアセトン溶液によって除去されることを特徴とする請求項１記載のＴ形のゲートの製造方法。

【請求項３】　前記第２パターン化されたフォトレジスト膜の除去後に　前記第１パターン化されたフォトレジスト膜を除去する工程を附加することを特徴とする請求項１記載のＴ形のゲートの製造方法。

【請求項４】　前記第１パターン化されたフォトレジスト膜が酸素プラズマを利用するドライエッチング方法によって除去されることを特徴とする請求項２記載のＴ形のゲートの製造方法。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は二重露光法による微細な形状のフォトレジストのパターンを利用してＴ形のゲートを形成する製造方法に関するものである。

【０００２】半導体素子の製作における、電極等の微細な線幅を形成することは素子の性能向上と集積度の向上等において一番重要な要素として作用し、特に微細な線幅をもつゲート電極としてＴ形のゲートを形成することは　その抵抗の減少のために効果的である。

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【０００３】

【従来の技術】一般的に、GaAsのMESFET（金属－半導体電界効果トランジスター）の特性はゲートの長さによって大幅に左右されるので　そのゲートの長さを減少させるための各種の製造方法が利用されてきた。

【０００４】このような製造方法から光学的なステッパーを使用するとマイクロメーター以下のゲートの長さをもつMESFETの製作が可能でないし、これを克服するため各種の方法を利用した。

【０００５】このような方法としては光学的なステッパーの性能の改善や工程の効率化による従来の光学的なステッパーの適用の限界を克服する方法　または電子線を利用した直記式方法（direct writing method）等がある。前記の光学的なステッパーにおける、光源としてエキシマレーザ（Excimer laser）等が利用されているが　半導体の工程に、このようなレーザーを利用して基板上に形成されたフォトレジスト膜を露光し現像して所定形状のパターンを形成する。

【０００６】このとき、露光される領域を可能な限り小さい領域とする場合には微細な形状を得ることができる。そのようなパターンの微細な程度は前記ステッパーから使用される光源の波長とレンズの特性によって左右される。

【０００７】一般的に、前記光学的なステッパーの光源は３６５ｎｍ、または４３５ｎｍのような短い波長の光を利用し、そしてレンズは１．４程度の開口数をもつレンズがビームの集束レンズとして利用される。微細なパターンを形成するために一般的にUV光源と利用して０．６～０．７μｍ解像度をもつ光学的なステッパーを利用する方法、コントラストを増加させる層を利用した方法、多層のフォトレジストを利用する方法、位相転移の方法等が適用されることができる。

【０００８】その中で、多層のフォトレジストを利用した方法等が微細なパターンの形成に代表的に利用される。以外の方法としてＸ－線やＥ－ビームを光源として利用した微細なパターンの形成方法を使用する場合には０．１μｍ以下のパターンの形成も可能である。これらの各種のパターンの形成方法はＴ形のゲートの形成に利用されることもできる。

【０００９】一般的なＴ形のゲートの形成方法は　臨時的なゲートの形成段階と臨時的なゲートの過度な食刻段階およびこの過度に食刻された領域を絶縁膜等で満たした後に新たなゲートのパターンを形成する段階を包含するものである。他のＴ形のゲートの形成方法は　微細なゲートを形成してから、その上にフォトレジスト膜または絶縁膜によって平坦化させる工程と　イオンミーリング等によってゲートを露出させてここに上層の金属膜を蒸着する工程を包含するものである。

【００１０】その上に、露光の感度が異なる多層のレジストを電子線または光によって露光および現像してか

ら　その上にT形の金属を蒸着し、続いてパターンを形成する方法もある。これらの方法はそれぞれ解像度や製作可能なゲートの大きさに少し位いの差異点があるか、すべて微細なパターンの形成方法として利用される場合　素子の性能か大幅に向上された。

【００１１】

【発明が解決しようとする課題】しかし、前記の方法はその製造工程か複雑であり　またその処理率においてもよくないので非効率的な問題点がある。

【００１２】したがって　本発明は上記の問題点を解決するために提案されたもので、前記各種の方法かもっている工程の複雑性を極めて単純化するために、光学的なステッパーの連続的な二重露光による丁形のゲートの製造方法を提供することにその目的かある。

【００１３】本発明のまた他の目的は長さを減少させたT形のゲートを使用してMESFET,HEMT等の特性を向上させ　それによって超高速および低雑音素子の製作を可能にすることにある。

【００１４】

【課題を解決するための手段】前記の目的をもつ本発明は従来に提案された各種の方法と異なりに従来の光学的なステッパーを利用して二重にフォトレジスト膜を露光して微細なパターンを形成してから　微細なパターンか形成された前記フォトレジスト膜をF層のフォトレジスト膜とし、そしてこの下層のフォトレジスト膜上に上層のフォトレジスト膜を形成してから金属膜を塗布してT形のゲートを形成することができる特徴かある。

【００１５】前記ステッパーによって露光するとき露光されるパターンか大きい場合にもパターンの端部から光の対比が大きくなって形状の形成か容易であり　現像後にフォトレジストの模様は鋭敏な端部の模様を現わし、そしてパターンの形成の幸裕度か広範囲である。

【００１６】このように　前記ステッパーを利用して形状が大きなパターンをもつフォトレンストを露光してから　基板の位置を移動させて、さらに露光すると　その露光されなかった領域はマスクの不透明なパターンの形状の大きさとマスクの移動距離（即ち　基板の移動距離）によって定められるので、極めて微細なパターンを形成することができる。

【００１７】具体的に、前記の目的を達成するための本発明の一つの特徴によると　二重露光を利用するT形のゲートの製造方法は、半絶縁のGaAs基板を準備する工程と　前記基板上に第１フォトレジスト膜を形成する工程と　不透明の領域が具備されたフォトマスクを利用して１X露光を実行して前記第１フォトレジスト膜内に第１露光されなかった領域を形成する工程と、前記T形のゲートの長さを考慮して少し位い移動された前記フォトマスクを使用して第２露光を実行して　前記第１露光されなかった領域内に第２露光されなかった領域を形成し、そして前記第２露光されなかった領域の両側には一回露光された領域を形成する工程と、現像工程を実行して現像されたT形の凹部分をもつ第１パターン化されたフォトレンスト膜を形成し、前記現像されたT形の凹部分は前記第２露光されなかった領域と前記一回露光された領域の一つの部分を除去することによって形成される工程と　熱処理の工程を実行する工程と　前記第１パターン化されたフォトレジスト膜上に第２パターン化されたフォトレジスト膜を塗布し　前記第２パターン化されたフォトレジスト膜か下の方向に広げられる開口部をもつ工程と　前記第２パターン化されたフォトレジスト膜上にそして前記基板の露出された表面上に金属層を塗布する工程と、前記第２パターン化されたフォトレンストを除去する工程とを包含する。

【００１８】この方法における、前記第２パターン化されたフォトレンスト膜はアセトン溶液によって除去される。この方法における、前記第２パターン化されたフォトレンスト膜の除去後に、前記第１パターン化されたフォトレジスト膜を除去する工程を附加する。この方法における、前記第１パターン化されたフォトレンスト膜か酸素プラズマを利用するドライエッチング方法によって除去される。

【００１９】前記の方法は、フォトレンスト膜を露光したとき、そのフォトレジスト膜が感光されるか　このとき感光される程度によりフォトレジスト膜か現像液によって現像される速度が大きく異なるというフォトレジストの特性を利用した技術てある。即ち　露光量により現像される速度か異なるため　フォトレンスト膜に露光された量か異なる部位があるとき、現像程度により残留したフォトレンスト膜の形態を任意にすることかできる。

【００２０】本発明は基板上のフォトレジスト膜を一次的に露光し基板の位置を移動させて　さらに露光することによって三段階の露光領域にフォトレジスト膜を区分して現像するので、微細なパターンのT形のゲートの形成を可能するようにしたものである。

【００２１】

【実施例】前記目的を達成するために本発明の実施例を添附の図１～図６に基づいて詳細に説明する。

【００２２】図１乃至図６は本発明の一つの実施によるT形のゲートを形成する方法を図示している断面図である。まず、図１は基板上に塗布されたフォトレジスト膜に一番目の露光工程を図示している断面図である。

【００２３】図１における　半絶縁のGaAs基板（１０）上にフォトレンスト膜（２０）を塗布し、その上部に不透明の領域（３１）をもつフォトマスク（３０）を配列してから、紫外線（３２）の露光によってゲートの領域を露光することを図示している。

【００２４】図２は前記基板（１０）の移動（またはフォトマスクの移動）による二重露光を実行して前記フォトレジスト膜（２０）の新たな露光領域を図示している断面図であって　前記図１に図示の露光工程後に前記フ

ォトマスクを所定の距離を移動した状態で再次露光すると　図２のように図１に図示の露光されなかった領域（２１）は再度露光されなかった領域（２２）と一回露光された領域（２３）として区分され、それ以外の領域は二回露光された領域（２４）である。

【００２５】前記露光されたフォトレジスト膜（２）の現像時にフォトレジスト膜が除去される厚さはそのフォトマスクの特性により少し変化するが　露光エネルギーが不足であるとフォトレジスト膜が完全に現像されない。

【００２６】図３は露光後に現像によって形成されたパターン化されたフォトレジスト膜（２０ａ）を図示している断面図であって、前記三つに区分された領域（２２，２３，２４）を所定の現像方法によって現像したときに残留するフォトレジストの形状は　図３のように、現像されたフォトレジスト膜（２０ａ）が図１に図示の露光されなかった微細な線幅よりもっと微細な幅をもつ形状として形成されるのである。

【００２７】このような方法によって形成されたパターン化されたフォトレジスト膜（２０ａ）に形成されたパターンの大きさは二次露光を遂行するために移動された前記基板（１０）または前記フォトマスク（３０）の移動の距離によって決定される。二次露光時にパターンの大きさより実際に形成しようとするパターンの大きさを考慮して基板またはマスクを所定の距離程移動させて露光することによって極めて微細な大きさのパターンの形成が可能である。

【００２８】ここで形成することができるパターンの大きさは主に二次露光時に位置の移動によって定義されるものであり、光源の波長等の光学的な要素により定められるものではない。

【００２９】したがって　本発明によって形成された微細なパターンは基板（１０）またはフォトマスク（３０）の位置の移動の正確度に依存する。

【００３０】前記のように形成されたフォトレジスト膜（２０ａ）の形状は開口部である微細なゲートの領域と　その周囲の薄い厚さの被覆された領域、そして厚い領域からなっている。

【００３１】このようなフォトレジスト膜のパターン（２０ａ）が形成された構造物は１５０℃以上の温度から熱処理される。この熱処理の工程は上層のフォトレジスト塗布時に微細なパターンが損傷されないようにするために実行されるものである。

【００３２】このように熱処理してからその上にフォトレジスト膜を塗布して、所定のパターンの上層のフォトレジスター膜（４０）が形成される。このフォトレジストパターン（４０）は下層のフォトレジストパターン（２０ａ）と分離されることができる。

【００３３】図４は図３の構造物上にパターン化された上層のフォトレジストパターン（４０）が形成されたことを図示している。即ち　前記構造物上に上層のフォトレジスト膜（１０）を塗布してから　マスクを使用して前記塗布された上層のフォトレジスト層（１０）を露光および現像すると図４のようなパターン化された上層のフォトレジストが形成される。このとき、上層のフォトレジストのパターンは逆相の傾斜をもつので、即ち深さの方向に広げられる形状をもっているので、垂直の方向性の蒸着によるリフトオフが実行されることができる。このようにすることによって上層のフォトレジストパターンはゲートの領域の大きさと無関に形成されることができる。

【００３４】このような状態から金属（５０）の蒸着によるＴ形のゲートの金属（１１）を図５に図示のように形成することができる。前記ゲート金属（５０）の蒸着後に　上層のフォトレジスト膜（４０）の除去の工程が実行される。即ち、前記上層のフォトレジスト膜（２０ａ）は所定の有機溶媒であるアセトン等に容易に溶解されてその上に形成された金属も除去される。しかし下層の劣化されたフォトレジストパターン（２０ａ）は場合により容易に溶解されない。

【００３５】このようなフォトレジストパターン（２０ａ）は固着されたそのままに素子に適用されることができ　また前記フォトレジストパターン（２０ａ）を除去する場合には酸素プラズマを利用したドライエッチングによって図６に図示のように除去してＴ形のゲート（５１）が形成される。

【００３６】

【発明の効果】このように形成されたＴ形のゲートの形状は従来の方法よりつぎのような長所をもっている。まず、微細な形状の形成における適用されるステッパーの解像度よりもっと微細なパターンの形成が可能である。次はリソグラフィーの工程の反復によってＴ－形状を作ることができるので工程の段階の減少により効率的にＴ形のゲートの形状を形成することができる。提案された方法はＴ形のゲートの形成を必要とする素子の製作、即ちMESFET,HEMT等に適用可能であり特性の向上を図ることができる。

【図面の簡単な説明】

【図１】本発明による製造工程を図示している断面図である。

【図２】本発明による製造工程を図示している断面図である。

【図３】本発明による製造工程を図示している断面図である。

【図４】本発明による製造工程を図示している断面図である。

【図５】本発明による製造工程を図示している断面図である

【図６】本発明による製造工程を図示している断面図である。

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【符号の説明】
１０　半絶縁のGaAs基板
２０　フォトレジスト膜
２０ａ　第１パターン化されたフォトレジスト
２２　露光されなかった領域
２３　一回露光された領域
２４　二回露光された領域

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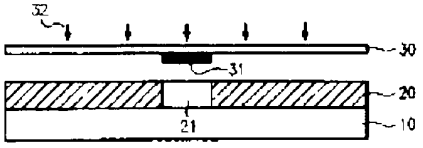
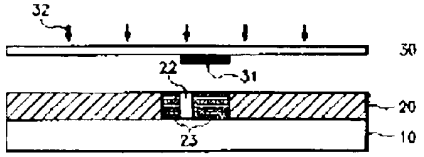
＊２４　現像されたフォトレジスト膜の微細な線幅
３０　マスク
３１　不透明の領域
３２　紫外線の露光
４０　第２パターン化されたフォトレジスト
５１　Ｔ形のゲート金属
＊　５０　塗布された金属層

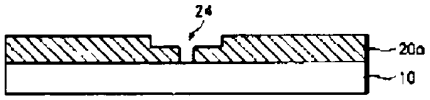
【図１】



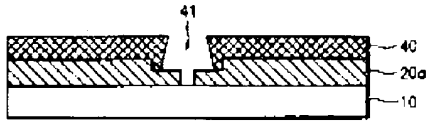
【図２】



【図３】

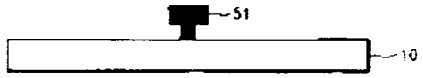


【図４】



【図５】

【図６】



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* NOTICES *

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CLAIMS

[Claim(s)]
[Claim 1] The process for which the GaAs substrate of a half-insulation is prepared in the manufacture method of the gate of T form of using double exposure, The process which forms the field which performed primary exposure using the process which forms the 1st photoresist film on the aforementioned substrate, and the photo mask which the opaque field possessed, and was not exposed the 1st time in the aforementioned 1st photoresist film, The second exposure is performed using the aforementioned photo mask moved for a while in consideration of the length of the gate of described [above] T type. the above -- the field which was not exposed the 2nd time in the field which was not exposed the 1st time -- forming -- and the above -- with the process which forms the field exposed once in the both sides of the field which was not exposed the 2nd time The photoresist film with a part for the crevice of T form developed by performing a development process patternized the 1st time is formed. The process formed when the amount of [by which development was carried out / aforementioned / of T form] crevice removes one portion of the field exposed once [aforementioned / field / which was not exposed the 2nd time / and aforementioned], the process which performs a heat treatment process, and the above -- the photoresist film patternized the 2nd time on the photoresist film patternized the 1st time -- applying -- the above -- with the process in which the photoresist film patternized the 2nd time has opening which can be extended in the direction of [lower] the above -- the process which applies a metal layer on the photoresist film patternized the 2nd time and the front face where the aforementioned substrate was exposed, and the above -- the manufacture method of the gate of T form characterized by including the process which removes the photoresist patternized the 2nd time
[Claim 2] the above -- the manufacture method of the gate of T form according to claim 1 characterized by removing the photoresist film patternized the 2nd time with an acetone solution
[Claim 3] the above -- after removal of the photoresist film patternized the 2nd time -- the above -- the manufacture method of the gate of T form according to claim 1 characterized by adding the process which removes the photoresist film patternized the 1st time
[Claim 4] the above -- the manufacture method of the gate of T form according to claim 2 characterized by removing the photoresist film patternized the 1st time by the dry etching method of using oxygen plasma

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] this invention relates to the manufacture method which forms the gate of T form using the pattern of the photoresist of the detailed configuration by the double exposure method.
[0002] Forming the line breadth with a detailed electrode etc. in manufacture of a semiconductor device acts as most important element in the improvement in a performance of an element, improvement in a degree of integration, etc., and it is effective because of reduction of the resistance. [of especially the thing for which the gate of T form is formed as a gate electrode with detailed line breadth]
[0003]
[Description of the Prior Art] Generally, since the property of MESFET (MES FET) of GaAs is sharply influenced by the length of the gate, various kinds of manufacture methods for decreasing the length of the gate are used.
[0004] When the optical stepper was used from such a manufacture method, the manufacture with the length of the gate below a micrometer of MESFET was not possible, and in order to conquer this, various kinds of methods were used.
[0005] There is a method of conquering the limitation of application of the conventional optical stepper by an improvement of the performance of a stepper optical as such a method or the increase in efficiency of a process or the account type method (direct writing method) of direct of having used the electron ray. Although the excimer laser (Excimer laser) etc. is used as the light source in the aforementioned optical stepper, the photoresist film formed on the substrate at the process of a semiconductor using such laser is exposed and developed, and the pattern of a predetermined configuration is formed.
[0006] At this time, when making the field exposed into the smallest possible field, a detailed configuration can be acquired. The detailed grade of such a pattern is influenced by the wavelength of the light source and the property of a lens which are used from the aforementioned stepper.
[0007] general -- the above -- an optical stepper's light source uses the light of short wavelength like 365nm or 436nm, and the lens in which a lens has about 1.4 numerical aperture is used as a focusing lens of a beam In order to form a detailed pattern, the method of using the optical stepper who generally uses with UV light source and has 0.6-0.7-micrometer resolution, the method using the layer to which contrast is made to increase, the method of using a multilayer photoresist, the method of phase transition, etc. are applicable.
[0008] The method which used the multilayer photoresist in it is typically used for formation of a detailed pattern. When using the formation method of a detailed pattern of having used X-ray and the E beam as the light source as the method of an except, formation of a pattern 0.1 micrometers or less is also possible. The formation method of these patterns of various kinds of is also applicable to formation of the gate of T form.
[0009] The general formation method of the gate of T form includes the stage which forms the pattern of the new gate, after filling with an insulator layer etc. the formation stage of the emergency-gate, too much chemical engraving stage of the emergency-gate, and this field that it etched too much. The

formation method of the gate of other T forms includes the process which carries out flattening by the photoresist film or the insulator layer on it, and the process which is made to expose the gate by ion milling etc. and carries out the vacuum evaporationo of the upper metal membrane here, after forming the detailed gate.
[0010] After exposing and developing the multilayer resist from which the sensitivity of exposure moreover differs by the electron ray or light, there is also the method of carrying out the vacuum evaporationo of the metal of T form, and forming a pattern continuously on it. Although these methods had some difference points of **** in resolution or the size of the gate which can be manufactured, respectively, when all were used as the formation method of a detailed pattern, the performance of an element improved sharply.
[0011]
[Problem(s) to be Solved by the Invention] However, the manufacturing process of the aforementioned method is complicated, and it has an inefficient trouble also in the rate of processing.
[0012] Therefore, it was proposed in order that this invention might solve the above-mentioned trouble, and in order to simplify extremely the complexity of the process which various kinds of aforementioned methods have, the purpose is in offering the manufacture method of the gate of T form by an optical stepper's continuous double exposure.
[0013] Other purposes of this invention raise properties, such as MESFET and HEMT, again using the gate of T form which decreased length, and it is in enabling manufacture of ultra high-speed and a low noise element by it.
[0014]
[Means for Solving the Problem] this invention with the aforementioned purpose uses as a lower layer photoresist film the aforementioned photoresist film with which the detailed pattern was formed after exposing the photoresist film to various kinds of methods and the difference which were proposed by the former doubly using the conventional optical stepper and forming the detailed pattern in them, and has the feature which can apply a metal membrane and can form the gate of T form after forming the upper photoresist film on this lower layer photoresist film.
[0015] Contrast of the edge of a pattern to light becomes large, when the pattern exposed when exposing by the aforementioned stepper is large, formation of a configuration is easy, the pattern of a photoresist expresses the pattern of an acute edge after development, and the degree of margin of formation of a pattern is wide range.
[0016] Thus, since the field which was not exposed will be appointed by the size of the configuration of the opaque pattern of a mask, and the travel (namely, travel of a substrate) of a mask if the position of a substrate is moved and it exposes further after exposing the photoresist in which a configuration has a big pattern using the aforementioned stepper, a very detailed pattern can be formed.
[0017] According to one feature of this invention for attaining the aforementioned purpose, concretely the manufacture method of the gate of T form of using double exposure The process for which the GaAs substrate of a half-insulation is prepared, and the process which forms the 1st photoresist film on the aforementioned substrate, The process which forms the field which performed primary exposure using the photo mask which the opaque field possessed, and was not exposed the 1st time in the aforementioned 1st photoresist film, The 2nd exposure is performed using the aforementioned photo mask by which **** movement was carried out for a while in consideration of the length of the gate of described [above] T type. the above -- the field which was not exposed the 2nd time in the field which was not exposed the 1st time -- forming -- and the above -- with the process which forms the field exposed once in the both sides of the field which was not exposed the 2nd time The photoresist film with a part for the crevice of T form developed by performing a development process patternized the 1st time is formed. The process formed when the amount of [by which development was carried out / aforementioned / of T form] crevice removes one portion of the field exposed once [aforementioned / field / which was not exposed the 2nd time / and aforementioned], the process which performs the process of heat treatment, and the above -- the photoresist film patternized the 2nd time on the photoresist film patternized the 1st time -- applying -- the above -- with the process in which the

photoresist film patternized the 2nd time has opening which can be extended in the direction of [lower] the above -- the photoresist film top patternized the 2nd time -- and the process which applies a metal layer on the front face where the aforementioned substrate was exposed and the above -- the process which removes the photoresist patternized the 2nd time is included

[0018] the above in this method -- the photoresist film patternized the 2nd time is removed by the acetone solution the above in this method -- after removal of the photoresist film patternized the 2nd time -- the above -- the process which removes the photoresist film patternized the 1st time is added the above in this method -- the photoresist film patternized the 1st time is removed by the dry etching method of using oxygen plasma

[0019] Although the photoresist film exposes the aforementioned method when a photoresist film is exposed, it is the technology using the property of the photoresist that the states where a photoresist film is developed with a developer by the grade exposed at this time differ greatly. That is, since the speed developed with light exposure differs, when there is a part from which the amount exposed by the photoresist film differs, the gestalt of the photoresist film which remained according to the development grade can be made arbitrary.

[0020] Since a photoresist film is classified and developed to three steps of exposure fields by this invention's exposing the photoresist film on a substrate in primary, and moving the position of a substrate and exposing further, it is made to carry out possible [of the formation of the gate of T form of a detailed pattern].

[0021]

[Example] In order to attain the aforementioned purpose, based on drawing 1 of appending of the example of this invention - drawing 6 , it explains in detail.

[0022] Drawing 1 or drawing 6 is a cross section illustrating the method of forming the gate of T form by one operation of this invention. First, drawing 1 is a cross section which is illustrating the exposure process of an eye most on the photoresist film applied on the substrate.

[0023] After arranging the photo mask (30) in drawing 1 which applies a photoresist film (20) on the GaAs substrate (10) of a half-insulation, and has an opaque field (31) in the upper part, it is illustrating exposing the field of the gate by exposure of ultraviolet rays (32).

[0024] Drawing 2 is a cross section which carries out double exposure by movement (or movement of a photo mask) of the aforementioned substrate (10), and is illustrating the new exposure field of the aforementioned photoresist film (20). After the exposure process of the illustration to aforementioned drawing 1 , if the aforementioned photo mask is re--degree-exposed where a predetermined distance is moved The field (21) where illustration was not exposed by drawing 1 like drawing 2 is classified as the field (22) which was not exposed again and a field (23) exposed once, and the other field is a field (24) by which two-times exposure was carried out.

[0025] Although the thickness from which a photoresist film is removed at the time of the development of a photoresist film (2) by which exposure was carried out [aforementioned] changes with the properties of the photo mask for a while, a photoresist film is not completely developed as exposure energy is insufficient.

[0026] Drawing 3 is a cross section illustrating the patternized photoresist film (20a) which was formed of development after exposure. The configuration of the photoresist which remains when the field (22, 23, 24) classified into the aforementioned three is developed by the predetermined development method Like drawing 3 , the developed photoresist film (20a) is formed in drawing 1 as a configuration with width of face more detailed than the detailed line breadth by which illustration was not exposed.

[0027] The size of the pattern formed in the patternized photoresist film (20a) which was formed by such method is determined by the distance of movement of the aforementioned substrate (10) moved in order to carry out secondary exposure, or the aforementioned photo mask (30). Formation of the pattern of a very detailed size is possible by a more nearly predetermined distance's moving a substrate or a mask in consideration of the size of the pattern which it is actually going to form from the size of a pattern at the time of secondary exposure, and exposing.

[0028] The size of the pattern which can be formed here is not mainly defined by movement of a

position at the time of secondary exposure, and is not defined with optical elements, such as wavelength of the light source.
[0029] Therefore, it depends on the accuracy of movement of the position of a substrate (10) or a photo mask (30) for the detailed pattern formed of this invention.
[0030] The configuration of the photoresist film (20a) formed as mentioned above consists of the field of the detailed gate which is opening, a field with which the thin thickness of the circumference was covered, and a thick field.
[0031] The structure with which the pattern (20a) of such a photoresist film was formed is heat-treated from the temperature of 150 degrees C or more. The process of this heat treatment is performed in order not to damage a detailed pattern at the time of the upper photoresist application.
[0032] Thus, after heat-treating, on it, a photoresist film is applied and the photoresistor film (40) of the upper layer of a predetermined pattern is formed. This photoresist pattern (40) is separable with a lower layer photoresist pattern (20a).
[0033] Drawing 4 is illustrating that the photoresist pattern (40) of the upper layer patternized on the structure of drawing 3 was formed. That is, if the photoresist layer (10) of the upper layer by which the application was carried out [aforementioned] using the mask is exposed and developed after applying the upper photoresist film (10) on the aforementioned structure, the photoresist of the patternized upper layer like drawing 4 will be formed. Since the pattern of the upper photoresist has the inclination of an antiphase at this time (i.e., since it has the configuration which can be extended in the depth direction), the lift off by the vacuum evaporationo of metaled directivity can be performed. The upper photoresist pattern can be formed in the size of the field of the gate, and non-Seki by doing in this way.
[0034] The metal (11) of the gate of T form by metaled (50) vacuum evaporationo can be formed in drawing 5 like illustration from such a state. After the vacuum evaporationo of the aforementioned gate metal (50), the process of removal of the upper photoresist film (40) is performed. That is, the metal which the photoresist film (20a) of the aforementioned upper layer was easily dissolved in the acetone which is a predetermined organic solvent, and was formed on it is also removed. However, the photoresist pattern (20a) with which the lower layer deteriorated is not easily dissolved by the case.
[0035] The dry etching which used oxygen plasma when [which could be applied to the element as it is, and removed the aforementioned photoresist pattern (20a)] it fixed removes such a photoresist pattern (20a) like illustration to drawing 6 , and the gate (51) of T form is formed.
[0036]
[Effect of the Invention] Thus, the configuration of the formed gate of T form has the following advantages from the conventional method. First, formation of a pattern more detailed than a stepper's resolution in formation of a detailed configuration applied is possible. Since T-configuration can next be made repeatedly [of the process of lithography], it can form the configuration of the gate of T form efficiently by reduction of the stage of a process. The proposed method can be applied to manufacture of the element which needs formation of the gate of T form, i.e., MESFET, HEMT, etc., and can aim at improvement in a property.

[Translation done.]

* NOTICES *

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TECHNICAL FIELD

[Industrial Application] this invention relates to the manufacture method which forms the gate of T form using the pattern of the photoresist of the detailed configuration by the double exposure method.
[0002] Forming the line breadth with a detailed electrode etc. in manufacture of a semiconductor device acts as most important element in the improvement in a performance of an element, improvement in a degree of integration, etc., and it is effective because of reduction of the resistance. [of especially the thing for which the gate of T form is formed as a gate electrode with detailed line breadth]

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PRIOR ART

[Description of the Prior Art] Generally, since the property of MESFET (MES FET) of GaAs is sharply influenced by the length of the gate, various kinds of manufacture methods for decreasing the length of the gate are used.
[0004] When the optical stepper was used from such a manufacture method, the manufacture with the length of the gate below a micrometer of MESFET was not possible, and in order to conquer this, various kinds of methods were used.
[0005] There is a method of conquering the limitation of application of the conventional optical stepper by an improvement of the performance of a stepper optical as such a method or the increase in efficiency of a process or the account type method (direct writing method) of direct of having used the electron ray. Although the excimer laser (Excimer laser) etc. is used as the light source in the aforementioned optical stepper, the photoresist film formed on the substrate at the process of a semiconductor using such laser is exposed and developed, and the pattern of a predetermined configuration is formed.
[0006] At this time, when making the field exposed into the smallest possible field, a detailed configuration can be acquired. The detailed grade of such a pattern is influenced by the wavelength of the light source and the property of a lens which are used from the aforementioned stepper.
[0007] general -- the above -- an optical stepper's light source uses the light of short wavelength like 365nm or 436nm, and the lens in which a lens has about 1.4 numerical aperture is used as a focusing lens of a beam In order to form a detailed pattern, the method of using the optical stepper who generally uses with UV light source and has 0.6-0.7-micrometer resolution, the method using the layer to which contrast is made to increase, the method of using a multilayer photoresist, the method of phase transition, etc. are applicable.
[0008] The method which used the multilayer photoresist in it is typically used for formation of a detailed pattern. When using the formation method of a detailed pattern of having used X-ray and the E beam as the light source as the method of an except, formation of a pattern 0.1 micrometers or less is also possible. The formation method of these patterns of various kinds of is also applicable to formation of the gate of T form.
[0009] The general formation method of the gate of T form includes the stage which forms the pattern of the new gate, after filling with an insulator layer etc. the formation stage of the emergency-gate, too much chemical engraving stage of the emergency-gate, and this field that it etched too much. The formation method of the gate of other T forms includes the process which carries out flattening by the photoresist film or the insulator layer on it, and the process which is made to expose the gate by ion milling etc. and carries out the vacuum evaporationo of the upper metal membrane here, after forming the detailed gate.
[0010] After exposing and developing the multilayer resist from which the sensitivity of exposure moreover differs by the electron ray or light, there is also the method of carrying out the vacuum evaporationo of the metal of T form, and forming a pattern continuously on it. Although these methods had some difference points of **** in resolution or the size of the gate which can be manufactured, respectively, when all were used as the formation method of a detailed pattern, the performance of an

element improved sharply.

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EFFECT OF THE INVENTION

[Effect of the Invention] Thus, the configuration of the formed gate of T form has the following advantages from the conventional method. First, formation of a pattern more detailed than a stepper's resolution in formation of a detailed configuration applied is possible. Since T-configuration can next be made repeatedly [of the process of lithography], it can form the configuration of the gate of T form efficiently by reduction of the stage of a process. The proposed method can be applied to manufacture of the element which needs formation of the gate of T form, i.e., MESFET, HEMT, etc., and can aim at improvement in a property.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, the manufacturing process of the aforementioned method is complicated, and it has an inefficient trouble also in the rate of processing.
[0012] Therefore, it was proposed in order that this invention might solve the above-mentioned trouble, and in order to simplify extremely the complexity of the process which various kinds of aforementioned methods have, the purpose is in offering the manufacture method of the gate of T form by an optical stepper's continuous double exposure.
[0013] Other purposes of this invention raise properties, such as MESFET and HEMT, again using the gate of T form which decreased length, and it is in enabling manufacture of ultra high-speed and a low noise element by it.

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MEANS

[Means for Solving the Problem] this invention with the aforementioned purpose uses as a lower layer photoresist film the aforementioned photoresist film with which the detailed pattern was formed after exposing the photoresist film to various kinds of methods and the difference which were proposed by the former doubly using the conventional optical stepper and forming the detailed pattern in them, and has the feature which can apply a metal membrane and can form the gate of T form after forming the upper photoresist film on this lower layer photoresist film.
[0015] Contrast of the edge of a pattern to light becomes large, when the pattern exposed when exposing by the aforementioned stepper is large, formation of a configuration is easy, the pattern of a photoresist expresses the pattern of an acute edge after development, and the degree of margin of formation of a pattern is wide range.
[0016] Thus, since the field which was not exposed will be appointed by the size of the configuration of the opaque pattern of a mask, and the travel (namely, travel of a substrate) of a mask if the position of a substrate is moved and it exposes further after exposing the photoresist in which a configuration has a big pattern using the aforementioned stepper, a very detailed pattern can be formed.
[0017] According to one feature of this invention for attaining the aforementioned purpose, concretely the manufacture method of the gate of T form of using double exposure The process for which the GaAs substrate of a half-insulation is prepared, and the process which forms the 1st photoresist film on the aforementioned substrate. The process which forms the field which performed primary exposure using the photo mask which the opaque field possessed, and was not exposed the 1st time in the aforementioned 1st photoresist film, The 2nd exposure is performed using the aforementioned photo mask by which **** movement was carried out for a while in consideration of the length of the gate of described [above] T type. the above -- the field which was not exposed the 2nd time in the field which was not exposed the 1st time -- forming -- and the above -- with the process which forms the field exposed once in the both sides of the field which was not exposed the 2nd time The photoresist film with a part for the crevice of T form developed by performing a development process patternized the 1st time is formed. The process formed when the amount of [by which development was carried out / aforementioned / of T form] crevice removes one portion of the field exposed once [aforementioned / field / which was not exposed the 2nd time / and aforementioned], the process which performs the process of heat treatment, and the above -- the photoresist film patternized the 2nd time on the photoresist film patternized the 1st time -- applying -- the above -- with the process in which the photoresist film patternized the 2nd time has opening which can be extended in the direction of [lower] the above -- the photoresist film top patternized the 2nd time -- and the process which applies a metal layer on the front face where the aforementioned substrate was exposed and the above -- the process which removes the photoresist patternized the 2nd time is included
[0018] the above in this method -- the photoresist film patternized the 2nd time is removed by the acetone solution the above in this method -- after removal of the photoresist film patternized the 2nd time -- the above -- the process which removes the photoresist film patternized the 1st time is added the above in this method -- the photoresist film patternized the 1st time is removed by the dry etching

method of using oxygen plasma
[0019] Although the photoresist film exposes the aforementioned method when a photoresist film is exposed, it is the technology using the property of the photoresist that the states where a photoresist film is developed with a developer by the grade exposed at this time differ greatly. That is, since the speed developed with light exposure differs, when there is a part from which the amount exposed by the photoresist film differs, the gestalt of the photoresist film which remained according to the development grade can be made arbitrary.
[0020] Since a photoresist film is classified and developed to three steps of exposure fields by this invention's exposing the photoresist film on a substrate in primary, and moving the position of a substrate and exposing further, it is made to carry out possible [of the formation of the gate of T form of a detailed pattern].

[Translation done.]

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EXAMPLE

[Example] In order to attain the aforementioned purpose, based on drawing 1 of appending of the example of this invention - drawing 6 , it explains in detail.
[0022] Drawing 1 or drawing 6 is a cross section illustrating the method of forming the gate of T form by one operation of this invention First, drawing 1 is a cross section which is illustrating the exposure process of an eye most on the photoresist film applied on the substrate.
[0023] After arranging the photo mask (30) in drawing 1 which applies a photoresist film (20) on the GaAs substrate (10) of a half-insulation, and has an opaque field (31) in the upper part, it is illustrating exposing the field of the gate by exposure of ultraviolet rays (32).
[0024] Drawing 2 is a cross section which carries out double exposure by movement (or movement of a photo mask) of the aforementioned substrate (10), and is illustrating the new exposure field of the aforementioned photoresist film (20) After the exposure process of the illustration to aforementioned drawing 1 , if the aforementioned photo mask is re--degree-exposed where a predetermined distance is moved The field (21) where illustration was not exposed by drawing 1 like drawing 2 is classified as the field (22) which was not exposed again and a field (23) exposed once, and the other field is a field (24) by which two-times exposure was carried out.
[0025] Although the thickness from which a photoresist film is removed at the time of the development of a photoresist film (2) by which exposure was carried out [aforementioned] changes with the properties of the photo mask for a while, a photoresist film is not completely developed as exposure energy is insufficient.
[0026] Drawing 3 is a cross section illustrating the patternized photoresist film (20a) which was formed of development after exposure. The configuration of the photoresist which remains when the field (22, 23, 24) classified into the aforementioned three is developed by the predetermined development method Like drawing 3 , the developed photoresist film (20a) is formed in drawing 1 as a configuration with width of face more detailed than the detailed line breadth by which illustration was not exposed.
[0027] The size of the pattern formed in the patternized photoresist film (20a) which was formed by such method is determined by the distance of movement of the aforementioned substrate (10) moved in order to carry out secondary exposure, or the aforementioned photo mask (30). Formation of the pattern of a very detailed size is possible by a more nearly predetermined distance's moving a substrate or a mask in consideration of the size of the pattern which it is actually going to form from the size of a pattern at the time of secondary exposure, and exposing.
[0028] The size of the pattern which can be formed here is not mainly defined by movement of a position at the time of secondary exposure, and is not defined with optical elements, such as wavelength of the light source.
[0029] Therefore, it depends on the accuracy of movement of the position of a substrate (10) or a photo mask (30) for the detailed pattern formed of this invention.
[0030] The configuration of the photoresist film (20a) formed as mentioned above consists of the field of the detailed gate which is opening, a field with which the thin thickness of the circumference was covered, and a thick field.

[0031] The structure with which the pattern (20a) of such a photoresist film was formed is heat-treated from the temperature of 150 degrees C or more. The process of this heat treatment is performed in order not to damage a detailed pattern at the time of the upper photoresist application.
[0032] Thus, after heat-treating, on it, a photoresist film is applied and the photoresistor film (40) of the upper layer of a predetermined pattern is formed. This photoresist pattern (40) is separable with a lower layer photoresist pattern (20a).
[0033] Drawing 4 is illustrating that the photoresist pattern (40) of the upper layer patternized on the structure of drawing 3 was formed. That is, if the photoresist layer (10) of the upper layer by which the application was carried out [aforementioned] using the mask is exposed and developed after applying the upper photoresist film (10) on the aforementioned structure, the photoresist of the patternized upper layer like drawing 4 will be formed. Since the pattern of the upper photoresist has the inclination of an antiphase at this time (i.e., since it has the configuration which can be extended in the depth direction), the lift off by the vacuum evaporationo of metaled directivity can be performed. The upper photoresist pattern can be formed in the size of the field of the gate, and non-Seki by doing in this way.
[0034] The metal (11) of the gate of T form by metaled (50) vacuum evaporationo can be formed in drawing 5 like illustration from such a state. After the vacuum evaporationo of the aforementioned gate metal (50), the process of removal of the upper photoresist film (40) is performed. That is, the metal which the photoresist film (20a) of the aforementioned upper layer was easily dissolved in the acetone which is a predetermined organic solvent, and was formed on it is also removed. However, the photoresist pattern (20a) with which the lower layer deteriorated is not easily dissolved by the case.
[0035] The dry etching which used oxygen plasma when [which could be applied to the element as it is, and removed the aforementioned photoresist pattern (20a)] it fixed removes such a photoresist pattern (20a) like illustration to drawing 6 , and the gate (51) of T form is formed.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is a cross section illustrating the manufacturing process by this invention.
[Drawing 2] It is a cross section illustrating the manufacturing process by this invention.
[Drawing 3] It is a cross section illustrating the manufacturing process by this invention.
[Drawing 4] It is a cross section illustrating the manufacturing process by this invention.
[Drawing 5] It is a cross section illustrating the manufacturing process by this invention.
[Drawing 6] It is a cross section illustrating the manufacturing process by this invention.
[Description of Notations]
10 GaAs Substrate of Half-Insulation
20 Photoresist Film
20a The photoresist patternized the 1st time
22 Field Which was not Exposed
23 Field Exposed Once
24 Field by Which Two-Times Exposure was Carried Out
24 Detailed Line Breadth of Developed Photoresist Film
30 Mask
31 Opaque Field
32 Exposure of Ultraviolet Rays
40 Photoresist Patternized 2nd Time
51 Gate Metal of T Form
50 Applied Metal Layer

[Translation done.]

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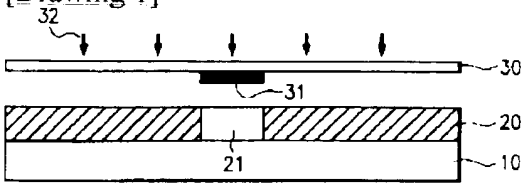
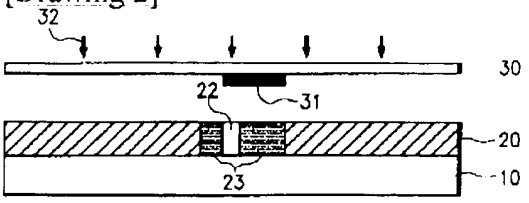
DRAWINGS

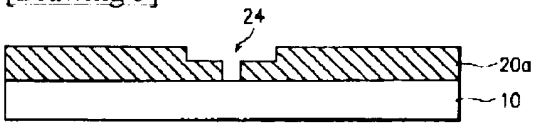
[Drawing 1]



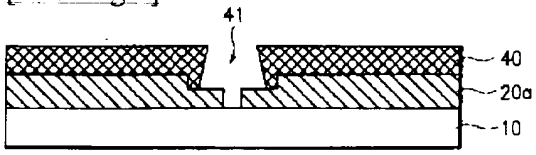
[Drawing 2]



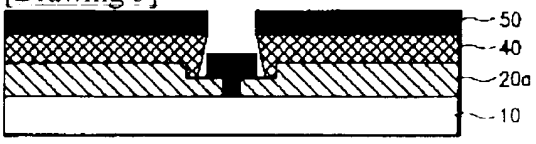
[Drawing 3]



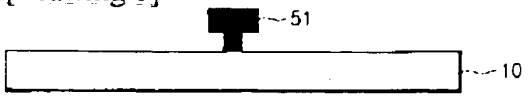
[Drawing 4]



[Drawing 5]



[Drawing 6]



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